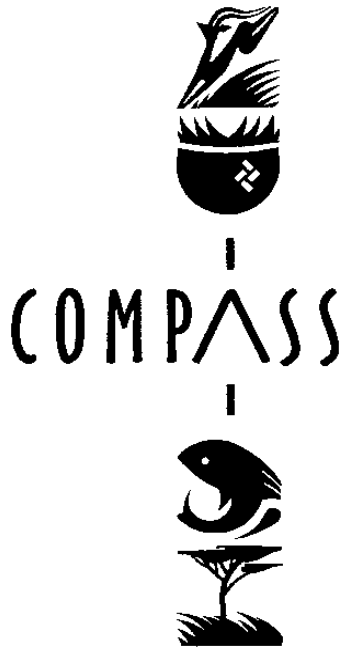
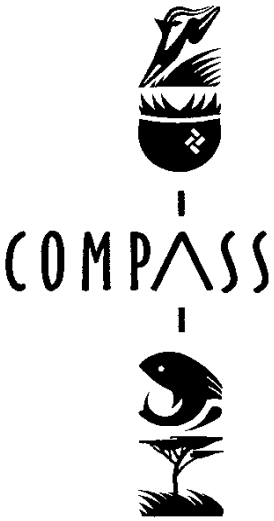


ADVANCED GIS FOR NATURAL RESOURCE MANAGERS

DOCUMENT 61
APRIL 2003



Community Partnerships for Sustainable Resource Management in Malawi

ADVANCED GIS FOR NATURAL RESOURCE MANAGERS

An advanced-level training course for District Environmental Officers in Malawi

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Acknowledgements

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Dr. Stanley Khaila, Director of Bunda College's Agricultural Policy Analysis Training Unit (APATU), which was the venue for the 3-week training course. APATU provided the laboratory for the training, accommodation and food for the participants, and transportation for the field trip to the Dzalanyama Forest Reserve. Dr. Khaila also made his personal computer available to us for the duration of the course.

Dr. Henry Mbeza, Director of The Agricultural Engineering Department, who supplied much of the computer equipment we used for the course. Dr. Mbeza also provided us with a generator which we used to keep the computers running during frequent and lengthy power cuts.

The District Environmental Officers (EDOs) from Machinga, Mangochi, Dedza, Chikwawa, Mzimba and Ntcheu, and the EDO Coordinator for the Environmental Affairs Department in Lilongwe, all of whom brought their own computers to Bunda to use during the course.

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USAID's Famine Early Warning System (FEWS) team in Lilongwe contributed valuable data, including time-series agricultural area, yield and production statistics for 154 Extension Planning Areas (EPA's).

The Danish International Aid Agency (DANIDA) provided the computer equipment and software the District Environmental Officers will be using to put their newly acquired mapping and GIS skills into practice.

Acronyms and Abbreviations

APATU	Agricultural Policy Analysis Training Unit at the University of Malawi's Bunda Agricultural College, Lilongwe
CBNRM	Community Based Natural Resources Management
COMPASS	Community Partnerships for Sustainable Resources Management (USAID-funded CBNRM initiative)
DANIDA	Danish International Aid Agency
EA	(Census) Enumeration Area
EAD	Environmental Affairs Department
EDO	District Environmental Officer
EIS	Environmental Information System (Unit)
EPA	Extension Planning Area
ESRI	Earth Systems Research Institute of Redlands, California (producers of ArcExplorer, ArcView and ARC/INFO GIS software)
FEWS	Famine Early Warning System (USAID-funded initiative)
GIS	Geographical Information System
GPS	Global Positioning System
IFPRI	International Food Policy Research Institute
LREP	Land Resources Evaluation Project
MEMP	Malawi Environmental Monitoring Project
NSO	National Statistical Office
OALS	Office of Arid Lands Studies
PA	Protected Area
PLUS	Public Lands Utilization Study
SOER	State of the Environment Report
STTA	Short-Term Technical Assistant
TA	Traditional Area
USAID	United States Agency for International Development
USGS	United States Geological Survey
UTM	Universal Transverse Mercator (map projection and coordinate system used for the COMPASS Malawi GIS Database)
WESM	Wildlife and Environmental Society of Malawi

Advanced GIS for Natural Resource Managers

A Training Course for District Environmental Officers

From 31 March to 19 April 2003, COMPASS conducted the third in its series of training courses – GIS for Natural Resource Managers. The Agricultural Policy Analysis Training Unit (APATU) of the University of Malawi's Bunda College of Agriculture was again the venue for the course. This latest session was comprised of two parts – the first week a repeat of the intermediate course that we first conducted in September of 2002, and the second and third weeks an advanced course for graduates of the intermediate-level training. We offered the intermediate course again for the benefit of 7 participants who were unable to attend last September. The complete chronology of the COMPASS GIS training program is as follows:

November 2000	Introductory Training in Applications of GIS and Remote Sensing
9 – 20 September 200, and 31 March to 5 April 2003	Intermediate GIS for Natural Resource Managers
7 – 19 April 2003	Advanced GIS for Natural Resource Managers

The short introductory course in 2000 provided the participants with some background in the theory and concepts behind geographical information system (GIS) and remote sensing technology, but because of time and resource constraints, there was little opportunity for practical, hands-on instruction in specific mapping and GIS applications. Course evaluations clearly pointed towards a more practical, less theoretical approach for the second and third parts of the training program. Having gained a good understanding of the scope and complexity of mapping science technology, the participants in the introductory course also suggested future training courses last longer than three days and incorporate field exercises as well as classroom sessions. With these suggestions in mind, COMPASS engaged David Craven as a short-term technical assistant (STTA) to design and conduct both the intermediate- and the advance-level training courses. Mr. Craven prepared this report as the document of record for the Advanced GIS for Natural Resource Managers training course[1].

In the main body of the report, Section 1 describes the objectives of the training program and the approach taken to meet those objectives. Section 2 outlines the contents and structure of the course, the techniques and procedures the participants learned, and the timetable for the classroom sessions and field trips. Section 3 describes the training materials used, and in particular the contents of the "COMPASS GIS Resource Kit". Section 4 draws conclusions from evaluations made by the course participants. Supplementary material attached to the main body of the report includes a list of participants (Attachment I), a detailed course schedule (Attachment II), and examples of

[1] This document reports only the names of the participants in the intermediate-level course conducted from 31 March to 5 April 2003. For details about the structure and content of that course, please see COMPASS Document 53, "GIS for Natural Resource Managers – An Intermediate-Level Training Course".

maps produced by members of the class (Attachment III). Extracts from the COMPASS GIS Resource Kit are also attached. These include documents describing the contents and structure of the COMPASS GIS Resource Kit CD (Attachment IV), a list of useful Web addresses (Attachment V), and the data dictionary describing the GIS layers, attribute data and satellite imagery contained in the GIS database used for the course (Attachment VI). The final attachment is a list of the reports and technical documents COMPASS has published since its inception more than four years ago (Attachment VII).

1. Training Course Objectives and Approach

The primary objective of the "Advanced GIS for Natural Resource Managers" training course was to develop the practical GIS and mapping skills EDOs and the other participants need to help them do their day-to-day jobs more effectively and more efficiently. One of the EDOs' main responsibilities is to coordinate production of bi-annual State of the Environment Reports (SOER's), so we designed the course to give them the skills they need to conduct spatial analyses and produce maps specifically for those reports. Because the concepts and techniques covered in the advanced-level course built directly onto those taught in the introductory and intermediate-level courses, all participants were required to have completed the earlier courses to qualify for a place on the advanced course.

Another goal for the advanced course was to introduce the participants to methods for getting new data into a GIS database. During the intermediate course it quickly became clear that the general, nationwide datasets provided by the trainer were inadequate for the detailed, sub-district analysis and mapping the EDOs need to do. Thus a large part of the advanced course was devoted to interpreting satellite imagery, collecting spatial data in the field, on-screen digitizing and editing, and linking new tabular datasets to spatial features in the GIS database.

Several of the participants complained that training courses they had attended before the COMPASS program left them with little to take back to their home offices that would help them in their daily work. To avoid falling into the same trap, we designed the course around technology that we knew the participants would have access to back in their respective district offices. All the participants confirmed they had received good quality computer equipment from the Danish International Development Agency (DANIDA) within the last 2 years, and that the equipment is in good working order. Some District Environmental Offices already have ArcExplorer and ArcView GIS software, but few have any suitable data they can analyze and produce maps with. To make sure all the participants had a complete set of resources to take home after the course, COMPASS gave each of them a copy of ArcExplorer and a 24-layer digital GIS database covering all of Malawi. In addition, the participants received printed and digital Landsat satellite data covering all of central Malawi and captured on 2 June 2002.

Learning how to do spatial analysis and computer mapping requires intensive and prolonged hands-on exposure to the equipment, software and database components of a GIS. Thus it was important that we engaged the trainees as active participants rather than as passive observers. Using Bunda's APATU computer laboratory as the venue for the course allowed each of the 14 participants full-time use of his or her own computer work

station; each participant received a copy of the COMPASS GIS Resource Kit (see Section 3); and each participant concluded the course by developing a mapping project focused on a district or region of their choice. Using this approach kept all 14 participants actively engaged throughout the course, and meant that each individual was able to work at his or her own pace and explore environmental issues relevant to his or her particular part of the country.

The trainer used several teaching methods to introduce new techniques and procedures and to reinforce the skills the participants were acquiring. For much of the time the class followed routines and procedures the trainer demonstrated using a laptop computer, a projector and a screen. On a number of occasions the trainer presented lectures and led class discussions on theoretical or conceptual aspects of computer mapping and GIS. The class made one full-day field trip to the Dzalanyama Forest Reserve and the area around Bunda Agricultural College. The purpose of the field trip was to ground-truth land cover interpretations of the satellite data the participants had made in the laboratory. We also made two shorter trips to the field to verify the land cover and land use in the immediate vicinity of the Bunda campus in more detail, and to learn how to operate Global Positioning System (GPS) receivers to collect field data. The participants spent the last day-and-a-half of the course working on individual projects with the trainer providing guidance and technical support on an as-needed basis. The approximate break-down of time devoted to each approach was as follows:

Demonstration/Hands-on Exercises	7 days (58%)
Lectures/Class Discussions	2 days (17%)
Field Trips	1.5 days (12.5%)
Individual Projects	1.5 days (12.5%)
Total	12 days (100%)

The blend of hands-on exercises, lectures, discussions, field trips and individual projects worked well to develop the participants' skills, build their confidence and maintain their interest throughout what was a long and intensive training course.

2. Course Contents and Schedule

COMPASS designed the training schedule to be flexible so that it could be modified as the course progressed. This flexibility was necessary in that it allowed us to accommodate the varying needs and interests of individual trainees, different learning speeds, and frequent problems with hardware and software. We used a general course schedule for overall direction and guidance, and daily outlines and objectives to plan and direct day-to-day activities. The trainer produced and distributed the outlines and objectives at the start of each day so that participants could complete unfinished exercises, revisit complex routines and techniques, and explore new procedures or areas of interest. Attachment II shows the course schedule and the daily outlines and objectives for the two-week program.

Day 1 of the advanced course was a review of the skills and techniques learned from the intermediate course. This was important to make sure that the participants, who had

attended two different intermediate-level courses, had a common understanding of basic GIS concepts and principles, and were equally comfortable with the techniques and procedures they would need for the more advanced work.

Day 2 began with each participant producing maps showing changes in land cover in Lilongwe District between 1973 and 1991. An example is presented as Map 1 in Attachment III. Then the participants learned basic principles of remote sensing and image interpretation, including the spatial and spectral characteristics of Landsat ETM+ data, how multispectral scanners record reflectance values from different bands of the electromagnetic spectrum, and how those reflectance values can be displayed in various color combinations to represent different features on the earth's surface. Each participant received prints of two sub-sets of a Landsat scene captured on 2 June 2002. The full-scene covers a large portion of central Malawi and parts of northern Mozambique. One of the printed sub-scenes covers the city of Lilongwe and the other covers an area surrounding the Bunda campus of approximately 30km east-west and 18km north-south. The participants also began to explore geo-referenced electronic versions of the two sub-scenes, provided to them on the COMPASS GIS Resource Kit CD.

The purpose of including image interpretation in the course was to demonstrate the value of remote sensing data as a source of spatial information. The COMPASS GIS database already includes two land cover layers, but they are very general both in terms of the limited number of land cover classes shown and the high degree of aggregation of spatial features. Furthermore, the land cover layers date from 1973 and 1991, neither of them representing the current distribution of land cover types in Malawi. With the 2002 data the participants would learn how to classify a satellite image and how to incorporate the results as a new layer in their GIS databases. This was an exercise in the long and complex process of updating a layer in a GIS database, and the participants spent much of the remainder of the course interpreting the image, checking their interpretations in the field, digitizing the new data, and comparing land cover for 2002 with the land cover from 1991 and 1973.

The participants interpreted the Bunda sub-scene of the Landsat ETM+ scene for this exercise. They interpreted land cover from both the printed and the electronic versions of the sub-scene. The initial step was to develop preliminary land cover classes to which the participants would assign features they identified on the image. The classification scheme was revised several times during the next few days as the class learned more about how actual conditions in the field are represented on imagery of this type. Other preparatory steps included clipping the 1973 and 1991 land cover layers to the area covered by the Landsat sub-scene, adjusting color/band combinations of the 2002 data to maximize the contrast between features belonging to different land cover classes, and drafting preliminary visual interpretations of the printed version of the 2002 image. This latter step helped the participants determine where to go in the field, what to look for, and how to collect and record field data for ground-truthing interpretations of remotely sensed data.

By the end of Day 4 the class had completed the preparatory work, and we spent Day 5 driving around the Bunda area, visiting examples of dambos, indigenous forest, forest plantations, areas of mixed agriculture, graveyards, and settlements. The route for the field trip took in the outskirts of Lilongwe, the settlements of Malingunde and Mitundu, the northern part of the Dzalanyama Forest Reserve, the two Kamuzu Reservoirs, and the intensively farmed area on and around the Bunda campus. The participants used a variety

of means for recording their observations. They used GPS receivers to record the locations of the sites we visited and a GPS log to note down the types of land cover observed at each site. Examples of each land cover type were photographed and referenced to the locations recorded in the GPS log.

Back in the laboratory, attention turned to how to translate the field data and visual interpretations into a new GIS layer. On Day 6 the participants learned how to create new point, line and polygon layers in ArcView, how to add features to those layers, how to edit those features, and how to enter descriptive data into a layer's attribute table. They also learned how to calculate the area and perimeter of polygon features and the length of line features using ArcView's sample script for calculating feature geometry. For the next three days the participants applied their new skills to creating four new layers in the GIS database, all based on information they had gleaned from the satellite image and the field trip. The four layers were a polygon layer for land cover, line layers for roads and rivers, and a point layer for man-made features such as settlements, graveyards and mines and quarries. Attributes included the area, perimeter and codes defining type for land cover features, codes distinguishing among the various types of mad-made features, and length fields for sections of roads and rivers. By the end of Day 9 the participants were producing maps of the land cover in the Bunda area as of 2 June 2002. An example is presented as Map 2 in Attachment III.

The main themes for Day 10 were procedures for joining new attribute data to features in an existing GIS database. EDOs are likely to find "joining" particularly useful because many of them have access to large volumes of tabular data that they would like to analyze and map. Knowing how to join their tables to features in a GIS layer will enable them to do this. To gain experience of the entire process from start to finish, the class was asked to join a large table of agricultural productivity data to the attribute table for the Extension Planning Areas (EPAs) layer. The complex process of joining databases required a number of steps to prepare both the geographic data (EPA polygons) and the tabular data (agricultural productivity statistics). For example, several EPAs were comprised of several polygon features, and participants had to "union" these so that each of the 154 EPAs in the GIS layer was represented as a single record in the attribute table. Prior to performing the union it was necessary to set rules to specify how ArcView should handle attribute values when multiple features were combined into one. This was important to ensure that, for example, area and population values were added together, but population density values were not, as that would have generated incorrect population density values for the aggregated EPA. The agricultural productivity table already had 154 records, but it did not have a field defining codes for the EPAs. The participants had to add this field and enter the correct code for each of the 154 EPAs. Once the data had been prepared, joining records from the EPA agricultural productivity table to records for corresponding features in the EPA GIS layer was a simple matter of activating the common fields and executing the "join" command. And with annual production figures for 13 crops in 154 EPAs over a period of 14 years at their fingertips, the participants were able to analyze and map some interesting changes in crop production over time and space.

Several of the participants had expressed interest in learning how to use a GPS receiver and how to transfer GPS coordinate data from the receiver into a GIS database. Instruction was provided during the field trip to Dzalanyama and during informal sessions on the campus of Bunda College. The participants learned basic operating procedures

such as how to save coordinates as waypoints, how to navigate to a waypoint, and how to switch between coordinate systems. The class also learned more advanced techniques for importing GPS coordinate data to ArcView. These techniques included on-screen digitizing, downloading data via a cable connecting a GPS receiver to a computer, and adding a database file (dbf) as an event theme in ArcView. The trainer focused on teaching general principles and procedures for data transfer because it is not particularly useful to teach people how to operate a specific make and model of receiver which they neither own nor have access to.

One of the most useful parts of the intermediate GIS training course held in September 2002 was the 2½ days participants devoted to conducting individual projects, reinforcing what they had learned, revisiting concepts and procedures they were unsure of, and exploring new techniques for processing and analyzing spatial data and presenting spatial information. Unfortunately only 1 day was available for the participants in the advanced course to pursue their own projects, and this limited the scope of their work and the quality of their outputs. The reasons we ran out of time were first that the scope and objectives of the advanced course were probably too ambitious, second that the size of the class was almost double the size of last September's class, and third, that the participants brought with them a wide range of skills and experience in GIS. The pace of the class was certainly held back by the slower learners, and this handicapped the more advanced students who were ready to tackle more sophisticated techniques and procedures.

Whereas during the early part of the course participants had followed the trainers' instructions and followed on-screen demonstrations of command sequences and procedures, for the project work they were largely given free reign with only minimal guidance from the instructor. Intended more to stimulate thinking and generate ideas than to provide step-by-step instructions, the written guidelines for the project work are presented in the text box at right.

Individual Spatial Analysis and Mapping Projects

Compile and print 2 or 3 layouts showing maps for the geographic area of your choice. The geographic area you choose should be a single region or district of Malawi. The layouts should illustrate environmental or natural resource management issues you feel are significant in your region or district. Include relevant statistical data in your layouts to quantify significant issues.

Examples of the issues you might analyze include the following:

- Population pressure threatening protected areas due to their close proximity to major settlements, roads or airports.
- Depletion of forest cover between 1973 and 1991.
- Changes in land cover in the area around Bunda College between 1973 and 2002.
- Changing patterns in crop production between 1984 and 1998.
- Relationships between densely populated areas and areas in which certain crops are grown.
- Pressure on surface water resources from intensive agricultural activity.

Even in the short time available, most of the participants did conduct interesting and creative analyses for their individual projects, and examples of their outputs are presented in Attachment III. Whilst some participants were content to compile simple descriptive maps from individual layers of data showing, for example, various categories of land cover (Maps 2 and 3), several explored complex spatial relationships among different physical and human characteristics of the landscape. A number of

participants mapped changes in forest and other classes of land cover between 1973 and 1991 (Maps 1, 4 and 6). The EDO from Kasungu investigated land cover change more closely, concluding that an increase in the area under tobacco cultivation has been responsible for much of the loss of Miombo woodland in his district (Map 5). Another EDO looked at the relationship between rice productivity and agro-climatic conditions in Salima District (Map 7), and in the last example, the EDO for Mangochi identified the potential threat to protected areas in Malawi's Southern Region posed by the close proximity of major settlements and transportation routes (Map 8). The maps shown in Attachment III are a small sample of the outputs generated during the course, but they clearly show how the EDOs and the other participants are able to apply their new skills to analyze and document important environmental and natural resource management issues in their respective districts.

3. Training Materials – The COMPASS GIS Resource Kit

The participants in the training course each received a COMPASS GIS Resource Kit. The kit was comprised of a loose-leaf binder of documents and a CD containing software, GIS data and electronic versions of the documents in the binder. Though similar in many ways to the kit used for the intermediate course, the kit for the advanced course included 3 prints of the June 2002 Landsat image – a large format print showing all of central Malawi, and two sub-scenes showing more detail for the city of Lilongwe and the area surrounding the Bunda campus. Participants also received digital versions of the two sub-scenes which they used as the basis for creating 2002 land cover data for the Bunda area.

Three of the documents from the resource kit are attached to this report. Those documents are:

Attachment IV.	Contents and Structure of the GIS for Natural Resource Managers CD
AttachmentV.	Useful Web Addresses
Attachment VI.	Data Dictionary for the COMPASS Malawi GIS Database

In addition to these documents, the binder contains a copy of the ESRI ArcExplorer User Manual, a number of papers describing GIS applications and case studies addressing a range of environmental and natural resources management issues, and several maps included as examples of outputs from GIS applications for natural resource managers. Most of the maps in the kit were produced by participants in the September 2002 intermediate-level training course.

The main purpose of distributing the resource kit was to give the participants all the materials they would need to establish a basic mapping and GIS capacity at their respective district offices. These include GIS software (ArcExplorer), GIS data (the COMPASS Malawi GIS Database) and instructional materials to help the EDO's use their new technical tools (ArcExplorer User Manual, case studies, sample maps, etc.).

The COMPASS Malawi GIS Database is one of the most important components of the resource kit. The database is comprised of twenty four layers of geographic data, many of which are attached to attribute tables that define the non-spatial characteristics of the geographic features. The text box at right lists the twenty-four geographic layers in the database. Three tables of agricultural statistics not attached to geographic layers are also included in the database. Formatted as Excel spreadsheets, these files give agricultural area, yield and production data for 154 Extension Planning Areas. The files contain data covering a 15-year period from 1984 to 1998 for five crops, and data for the five years from 1994 to 1998 for eight crops. Attachment VI presents a detailed description of both the spatial and the attribute data contained in the COMPASS Malawi GIS Database.

1. 1998 Census Enumeration Area
2. Agricultural Schemes
3. Agroclimatic Zones
4. Airports
5. COMPASS Districts
6. Districts
7. Extension Planning Areas
8. Forest Reserves
9. Lakes
10. Landcover 1973
11. Landcover 1991
12. Major Settlements
13. National Boundary
14. National Parks
15. Proposed Forest Reserves
16. Protected Areas
17. Regions
18. Rivers and Streams
19. Soils
20. Traditional Areas
21. Transportation Routes
22. UTM Grid
23. Vegetation
24. Wildlife Reserves

The database is large and it contains a lot of very useful spatial information, but its value to the participants in this training course will be more as a learning resource than as source of useful information. Most of the layers are national in scope and contain little detail for sub-district level analysis and mapping, which is what EDO's are generally interested in. This limitation demonstrated an important principle to the participants - that **spatial datasets prepared by third parties rarely meet a user's specific requirements for detail, accuracy, content and geographic scope**. The database is perfectly adequate for a training course, but the EDOs will have to develop their own detailed, up-to-date, local databases if they are to apply their new skills to help address environmental issues in their respective districts.

4. Course Evaluation and Conclusions

Thirteen of the fourteen participants completed a simple course evaluation form. The respondents rated all aspects of the course at least "satisfactory", with the exception of one participant who considered the venue and location to be "poor". Most of the participants rated the contents of the course, the hands-on approach, the instructor, the materials used and the relevance of what they learned to their daily work as "very good". The majority also considered the pace of instruction, the venue and location, the field trip and the accommodation and food to be "good" or "very good". The laboratory and computer equipment received the lowest scores, with a slim majority rating the facilities as only "satisfactory". Even this lukewarm response represents a marked improvement over the response to the same question last autumn, due largely to the fact that the

computers we had available for this course were much more powerful and in much better condition than those we used in September 2002.

The table below summarizes the responses from the 13 participants who completed the course evaluation form.

		Very Good	Good	Satisfactory	Poor	Very Poor
1.	The contents of the training course	10	3			
2.	The hands-on method of teaching	13				
3.	The speed at which we covered the work	4	6	3		
4.	The laboratory and computer equipment	3	3	7		
5.	The instructor	13				
6.	The venue and location at Bunda	2	5	5	1	
7.	The field trip[2]	4	8	1		
8.	The GIS Resources Kit	10	2	1		
9.	Accommodation and food		8	5		
10.	The relevance of what you learned to your daily work or research	11	2			

Asked what they liked most about the course, most participants highlighted the hands-on approach to teaching GIS and the relevance of the contents of the course to their daily work. Having experienced other teaching methods such as lectures, presentations and seminars, the participants were very pleased to be given the opportunity to develop practical skills that they will be able to apply to solving problems and addressing issues back in their respective districts.

The main complaint about the course was that we tried to do too much in too short a period of time. This is a valid complaint, particularly from the less advanced participants who struggled to absorb the large amount of material covered. On the other hand, a number of the more advanced participants felt they were being held back to give other members of the class time to catch up. Getting the balance right for a large group of students with a range of experience and competence in computer operations, geography and GIS is always difficult. Solutions for future training courses would be to split the group into two or more sections based on current levels of competence, to include more "individual project" time to allow participants to proceed at their own pace, to increase the length of the course, and/or to reduce the amount of material covered during the time available. Some combination of these four options will most likely provide the best solution.

[2] Only 12 responses to this item because one participant was unable to join us on the field trip

Several of the participants expressed particular interest in learning more about the use of GPS receivers for collecting coordinate data from the field and incorporating those data into GIS databases. Some time was spent working with GPS receivers during this advanced course, but a longer, more focused session will certainly be needed to give the participants the skills and experience they need. Ideally the EDOs and their fellow trainees would receive training using a standard make and model of GPS receiver with a common set of operating instructions.

The Advanced GIS for Natural Resource Managers training course was effective in that it developed knowledge and skills that the trainees themselves consider to be useful and relevant to their work. The EDO's have taken their skills back to the districts and will hopefully have the opportunity to practice the techniques and procedures they learned on a regular and frequent basis. Computer mapping and GIS is not something that can be learned in 2 or 3 weeks in a classroom setting – daily work with the software and the databases is necessary to reinforce what was learned in the classroom and maintain familiarity with the abstract concepts, strange jargon and complex command sequences associated with GIS.

Many of the participants expressed frustration at being limited to the canned dataset provided as part of the resource kit. Though very rich at the national level, the database provides very little detail about the geography within individual districts. Clearly GIS will only be useful to the EDO's if they have access to data that show spatial variations *within* districts as well as differences between districts. The main focus of the advanced training course was to teach methods for adding new data to a GIS database. Participants learned how to interpret satellite imagery, verify their interpretations in the field and develop new and expanded GIS layers through a combination of on-screen digitizing, attribute entry and joining tables. Hopefully they will now have the opportunity to apply their new skills to develop richer, more detailed spatial databases for their respective districts.

The trainees each received a copy of ArcExplorer software as part of the COMPASS GIS Resource Kit, but not all of them have access to ArcView in their work places. ArcExplorer's functionality is quite limited, and although useful as a means of introducing the participants to computer mapping and GIS concepts, techniques and procedures, it will be of very limited practical use to the EDO's in their daily work. COMPASS should consider purchasing ArcView 3.3 licenses for course participants who do not currently own the software.

Attachment I

List of Participants

1. Lingstone Chiona, District Environmental Officer, Mangochi
2. Jacinta Chipendo, Environmental Officer, EAD, Lilongwe
3. Suzgo Gondwe, District Environmental Officer, Zomba
4. Wellington Kafakalawa, Lecturer, Mzuzu University
5. Stanley Kamtsitsi, District Environmental Officer, Dedza
6. McLeod Kawerama, District Environmental Officer, Chikwawa
7. Luke Malembo, COMPASS Information Management Specialist, COMPASS, Blantyre
8. Symon Mandala, District Environmental Officer, Mzimba
9. Biswick Mlaviwa, District Environmental Officer, Machinga
10. Osborne Ngwali, Project Assistant, Wildlife and Environmental Society of Malawi (WESM), Mwanza
11. Welton Phalira, EDO Coordinator, EAD, Lilongwe
12. Stephen Sakhama, District Environmental Officer, Kasungu
13. Clement Tikiwa, District Environmental Officer, Ntcheu
14. Mathews Tsirizeni, District Environmental Officer, Salima

Attachment II

Training Course Schedule and Daily Outlines and Objectives

Week 1

Date	Time	Topic
Monday, April 7th	AM	Introduction, course objectives and outline
	PM	Review of material from intermediate course
Tuesday, April 8th	AM	Working with satellite imagery
	PM	Principles of photo-interpretation
Wednesday, April 9th	AM	Mapping land cover around Bunda from Landsat imagery
	PM	Mapping land cover around Bunda from Landsat imagery
Thursday, April 10th	AM	Field trip - Ground-truthing land cover interpretation around Bunda
	PM	
Friday, April 11th	AM	Revising land cover interpretations and preparing for digitizing
	PM	Editing geographic data in ArcView
Saturday, April 12th	AM	Editing geographic data in ArcView (continued)
	PM	Review of Week 2 – class discussion

Week 2

Date	Time	Topic
Monday, April 14th	AM	Continue mapping land cover around Bunda from Landsat imagery
	PM	Continue mapping land cover around Bunda from Landsat imagery
Tuesday, April 15th	AM	Joining tables of statistics to existing attribute tables in an ArcView theme
	PM	
Wednesday, April 16th	AM	Revising land cover interpretations and preparing for digitizing
	PM	On-screen digitizing to create new data
Thursday, April 17th	AM	Digitizing Bunda land cover maps
	PM	Complete digitizing of land cover maps
Friday, April 18th	AM	Individual spatial analysis and mapping projects
	PM	Continue individual projects
Saturday, April 19th	AM	Complete individual projects
	PM	Review and conclude training course

Day 1 – Outline and Objectives

7th April 2003

- Greetings and introductions

- Preparing for the advanced course:
    a. Outline and Objectives
    b. Loading ArcView software
    c. Loading the COMPASS GIS for Malawi database

- Review of the material from the intermediate course:
    a. Views, Layouts, Tables and Scripts
    b. Moving around the View window
    c. Map elements of the Layout window
    d. Working with Tables – querying, calculating fields, sorting, selecting, obtaining statistics
    e. Symbolizing spatial data – the Legend Editor and Symbol Palette
    f. Conducting spatial analysis – clipping, buffering, selecting-by-theme
    g. Calculating spatial properties – area, perimeter and length
    h. Exporting Layouts and printing maps

- Practical exercise - looking at changes in land cover in Lilongwe District from 1973 - 1979

Day 2 – Outline and Objectives

8th April 2003

- Finish compiling and print land cover change detection maps for Lilongwe District, 1973 - 1991

- Fundamentals of remote sensing and image interpretation

- Working with satellite images and multispectral image data – the Landsat ETM+ scene for central Malawi, June 2002

- Preparing the land cover theme for editing and updating

- Editing spatial data – the 1991 land cover theme

Day 3 – Outline and Objectives

9th April 2003

- Review results of Quick Quiz No. 1
- Clipping the 1991 Land Cover theme to the area covered by the Bunda Landsat sub-scene
- Registering the 1991 Land Cover theme for Bunda to the Landsat image
- Developing a preliminary land cover classification for the 2002 update
- Principles of visual image interpretation – color, tone, pattern, proximity, texture
- Preparing the Bunda image for visual photo-interpretation
- Drafting preliminary visual interpretations

Day 4 – Outline and Objectives

10th April 2003

- Continue developing land cover classification for the 2002 Landsat image for Bunda
- Continue drafting visual interpretations of the 2002 Landsat image for Bunda
- Bird's-Eye-View – a short walk up a nearby hill for an overview of the Bunda area
- Preparing for tomorrow's day in the field – where to go, what to take, what to look for, how to record field data
- Introducing on-screen digitizing – creating new themes, adding features to a theme, entering attributes of those new features

Day 5 – Outline and Objectives

11th April 2003

- Field trip to Malingunde, Dzalanyama Forest Reserve, Kamuzu Dam and Mitundu to ground truth classifications of the June 2002 Landsat image

Day 6 – Outline and Objectives

12th April 2003

- Developing on-screen editing skills – general and interactive snapping, digitizing contiguous polygons, editing vertices
- Calculating the area and perimeter of features in a new polygon theme, and the length of features in a new line theme
- Adding a point, a line and a polygon theme to the COMPASS GIS database

Day 7 – Outline and Objectives

14th April 2003

- Finalize the classification scheme for the 2002 Bunda Landsat image
- Digitize the point theme for graveyards, settlements and quarries/mines
- Digitize the line theme for roads and the line theme for rivers
- Digitize the polygon theme for land cover

Day 8 – Outline and Objectives

15th April 2003

- Complete digitizing the point theme "Bunda Man Made Features 2002"
- Complete digitizing the line theme " Bunda Roads 2002"
- Complete digitizing the line theme "Bunda Rivers 2002"
- Complete digitizing the polygon theme "Bunda Land Cover 2002"
- Preparing to enter attribute data for each of the 4 new themes
- Calculating the "*Area*" attribute field for "Bunda Land Cover 2002" and the "*Length*" attribute field for "Bunda Roads 2002" and "Bunda Rivers 2002"
- Code the features in the "Bunda Land Cover 2002" and "Bunda Man Made Features 2002" themes

Day 9 – Outline and Objectives

16th April 2003

- Editing attributes revisited – creating new fields, calculating spatial properties, entering data into individual cells, calculating fields or parts of fields
- Structure the attribute tables for the 4 new Bunda themes
- Fill all the cells in the 4 attribute tables either by entering values on a cell-by-cell basis, by calculating fields, or by using the "Calculate Feature Geometry" script
- Using "Hot Link" to display photographs from the field
- Clip "Bunda Land Cover 2002", "Bunda Roads 2002" and "Bunda Rivers 2002" using the frame theme for the Bunda Landsat image
- Prepare to conduct an analysis monitoring changes in land cover between 1973 and 2002

Day 10 – Outline and Objectives

17th April 2003

- Enter data into all the cells in the "Clipped Bunda Land Cover 2002" attribute table either by entering values on a cell-by-cell basis, by calculating fields, or by using the "Calculate Feature Geometry" script
- Joining tables – using the FEWS agricultural production data
- Individual projects – prepare graphics, tables and text to describe environmental issues in a region of Malawi of your choice. Projects to be completed and submitted by noon on Saturday, April 19th.

Day 11 – Outline and Objectives

18th April 2003

- Completing the "join" between the attribute table for the Extension Planning Areas theme and the FEWS agricultural productivity table.

- Transferring coordinate data from a GPS receiver to an ArcView Shape File.

Individual Spatial Analysis and Mapping Projects.

Compile and print 2 or 3 layouts showing maps for the geographic area of your choice. The geographic area you choose should be a single region or district of Malawi. The layouts should illustrate environmental or natural resource management issues you feel are significant in your region or district. Include relevant statistical data in your layouts to quantify significant issues.

Examples of the issues you might analyze include the following:

- Population pressure threatening protected areas due to their close proximity to major settlements, roads or airports.
- Depletion of forest cover between 1973 and 1991.
- Changes in land cover in the area around Bunda College between 1973 and 2002.
- Changing patterns in crop production between 1984 and 1998.
- Relationships between densely populated areas and areas in which certain crops are grown.
- Pressure on surface water resources from intensive agricultural activity.

You have until 12 noon on Saturday to complete your projects. Try to print drafts of your layouts before the end of class on Friday to give you time on Saturday morning to edit and improve them before printing your final versions.

Day 12 – Outline and Objectives

19th April 2003

- Complete individual spatial analysis and mapping projects and print final layouts

- Export the layouts to .WMF format and give a copy of the WMF file to the instructor

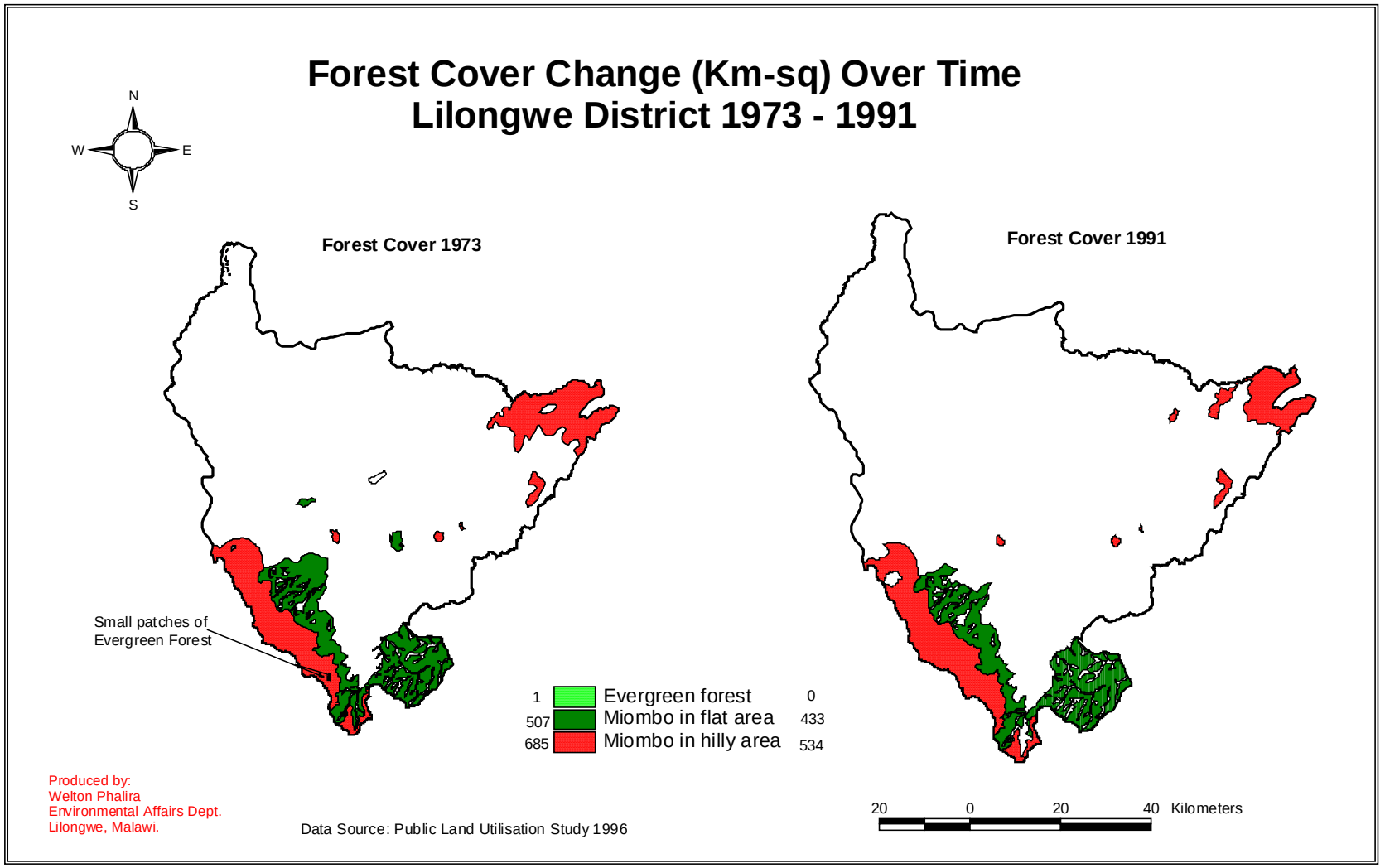
- Back up your data – write down the exact path and name of of key project and shape files and copy them to diskette

- Complete course evaluation and return to instructor

- Closing and reception

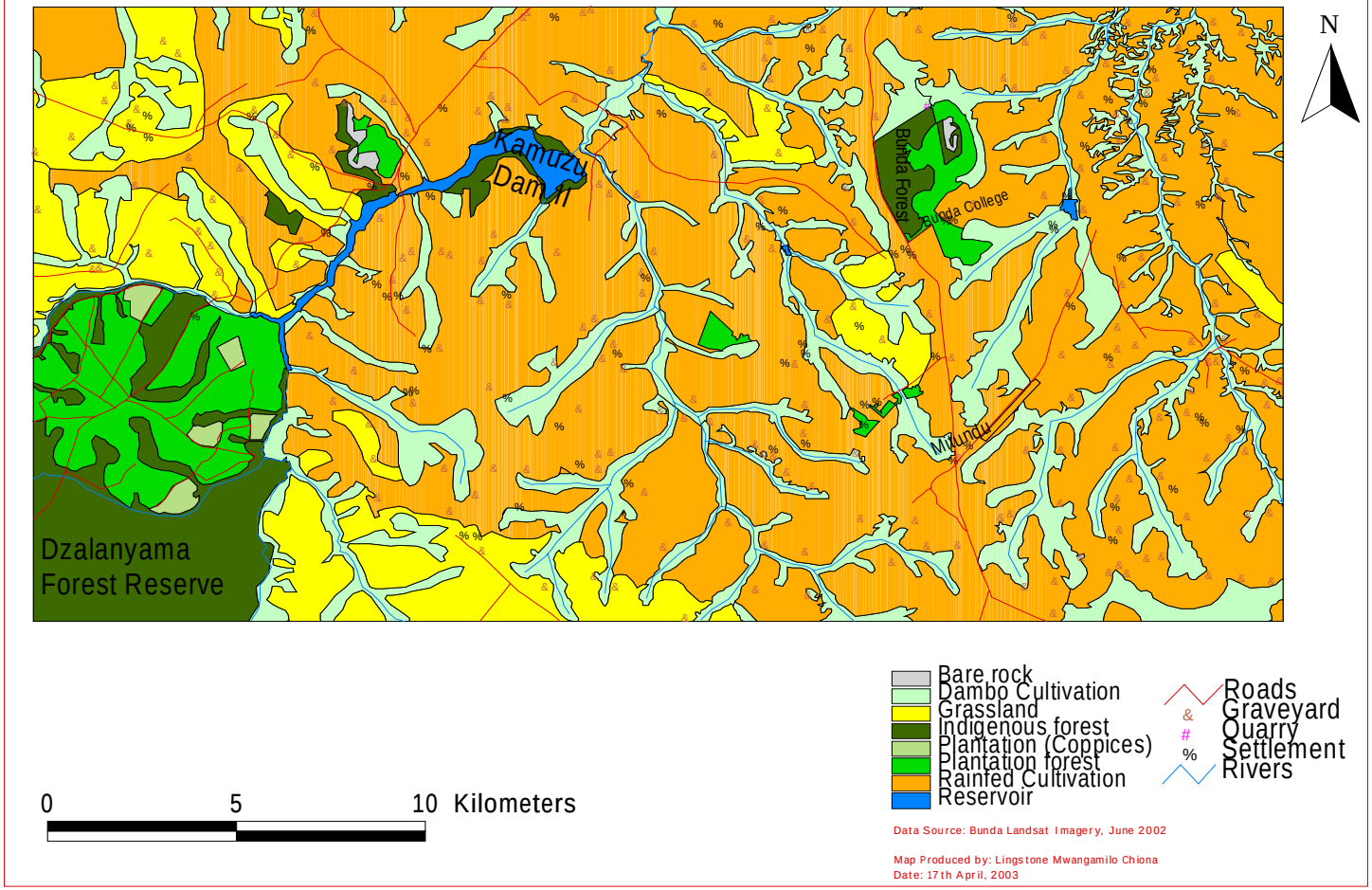
Attachment III

Examples of Maps Produced by Participants

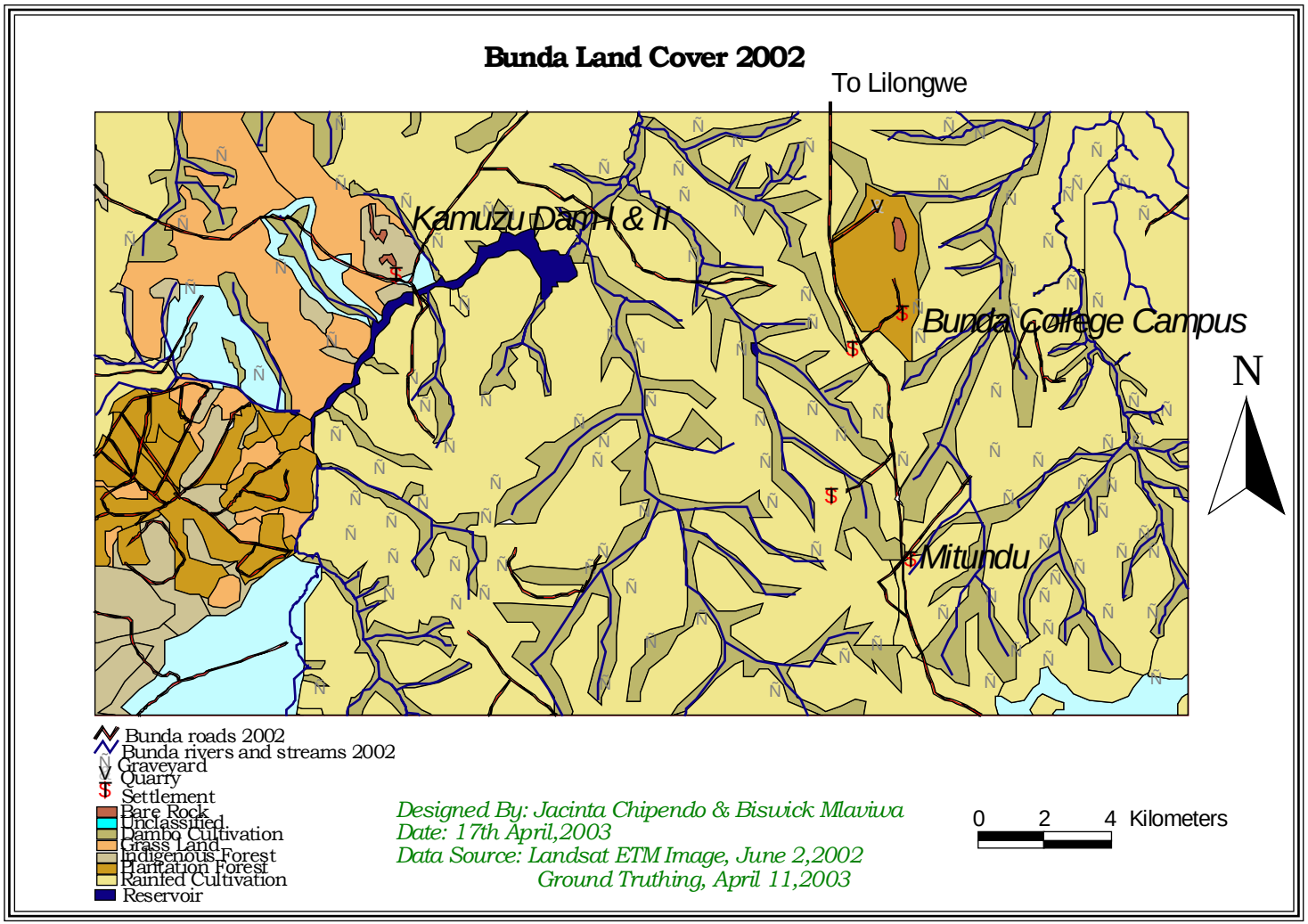


Map 1
Forest Cover Change in Lilongwe District, 1973-1991
Prepared by Mathews Tsirizeni, District Environmental Officer, Salima

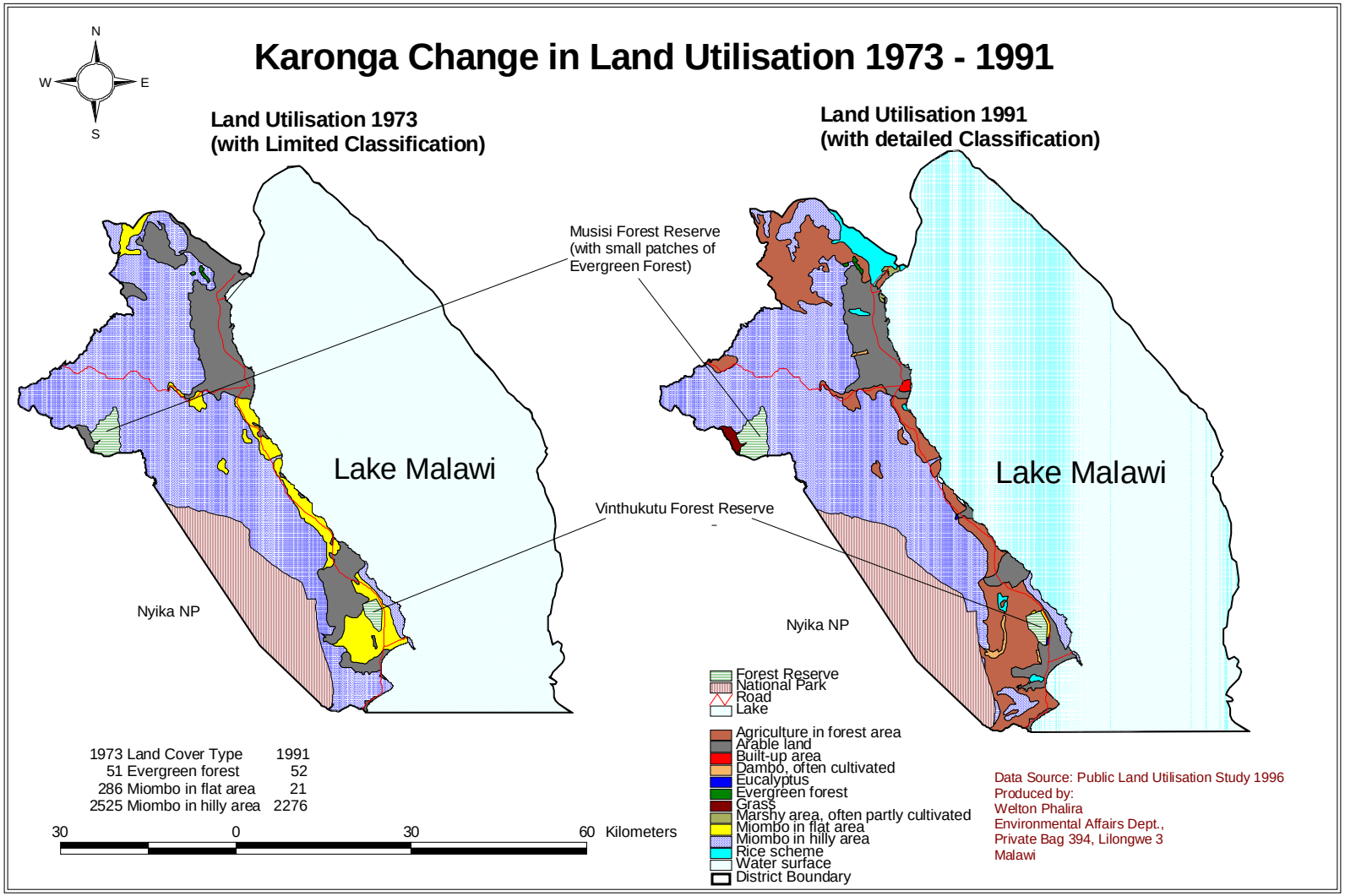
Fig 1: Bunda Land Cover 2002



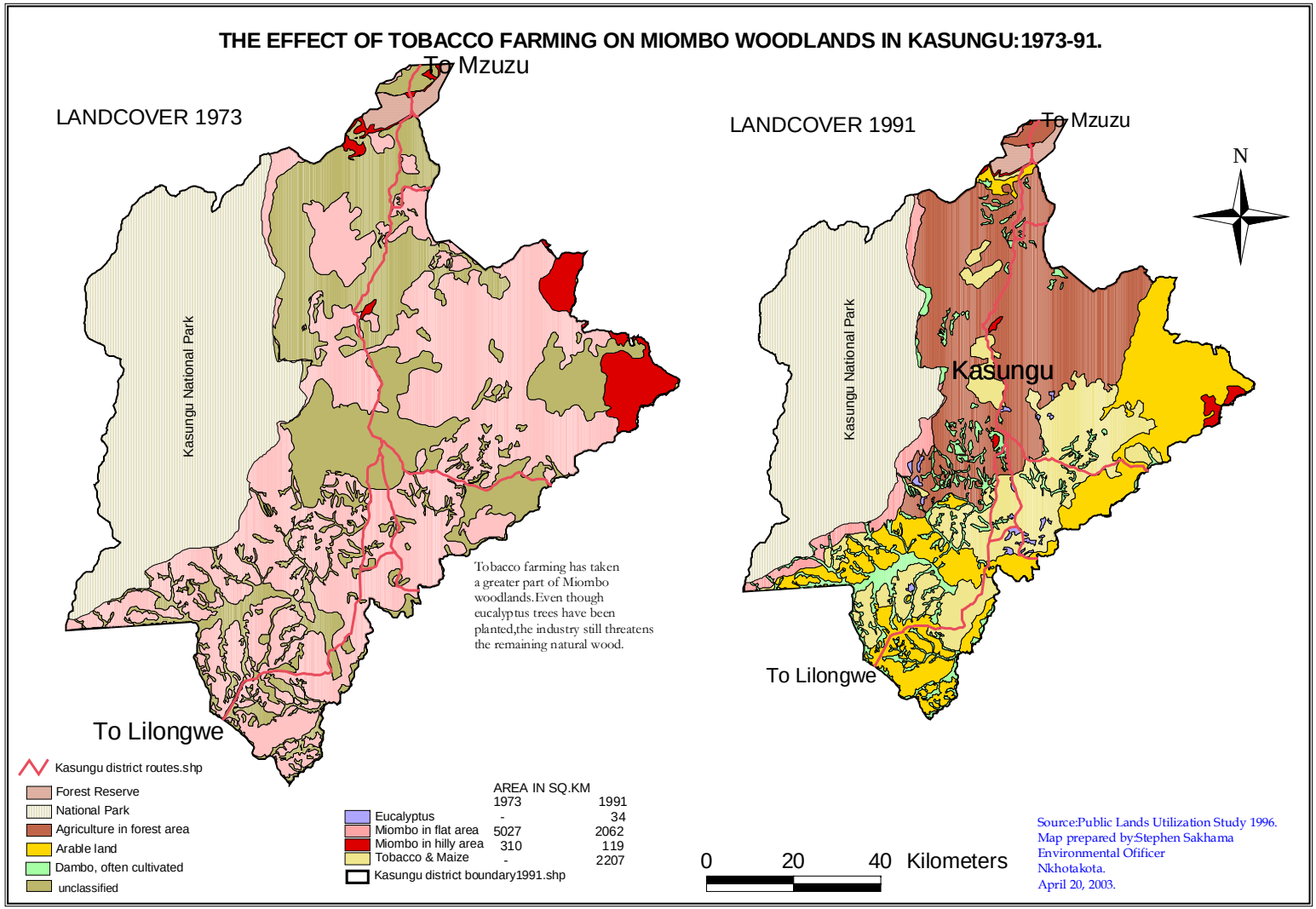
Map 2
Bunda Land Cover 2002
Prepared by Lingstone Chiona, District Environmental Officer, Mangochi



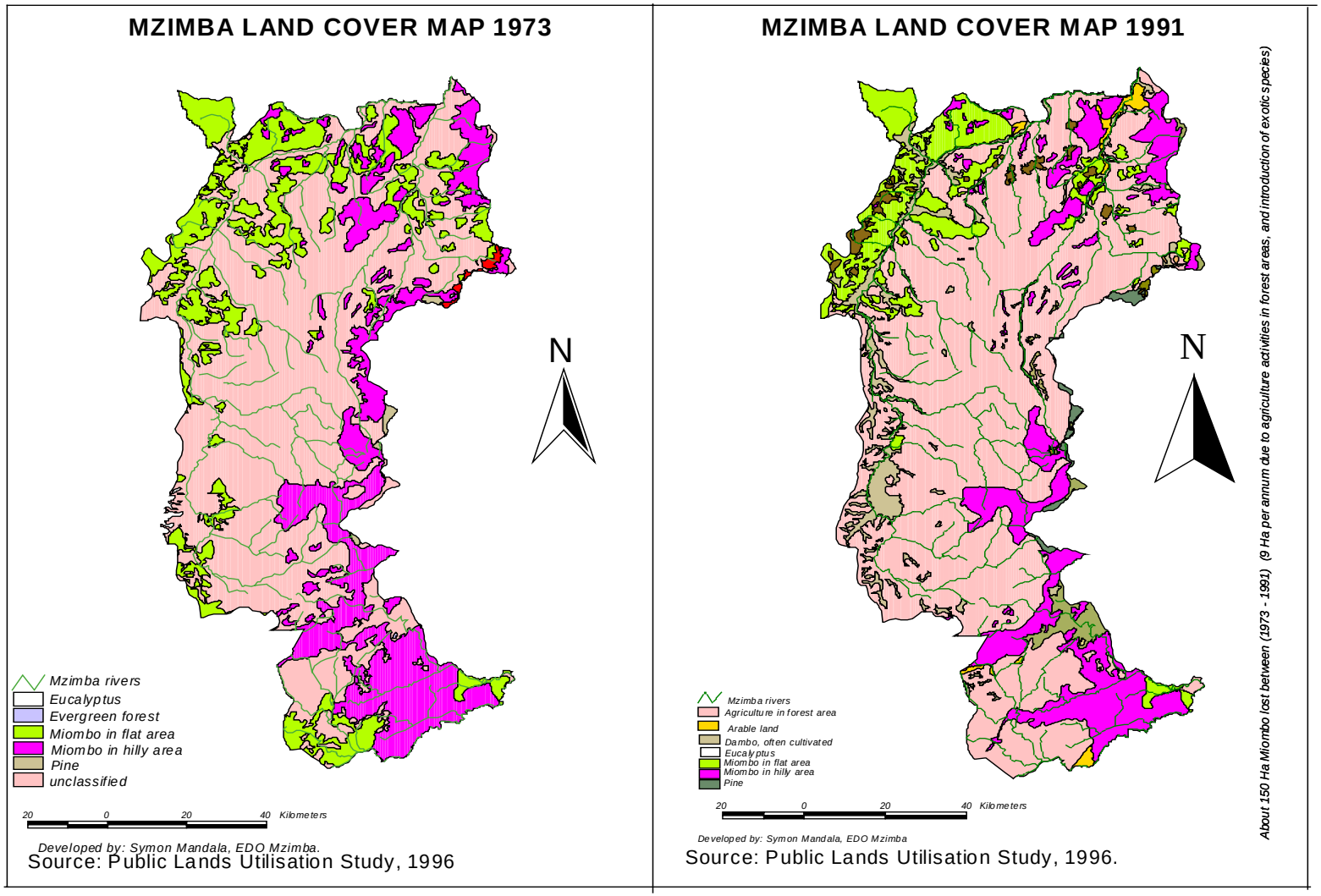
Map 3
Bunda Land Cover 2002
Prepared by Jacinta Chipendo, Environmental Affairs Department, Lilongwe, and Biswick Mlaviwa, District Environmental Officer, Machinga



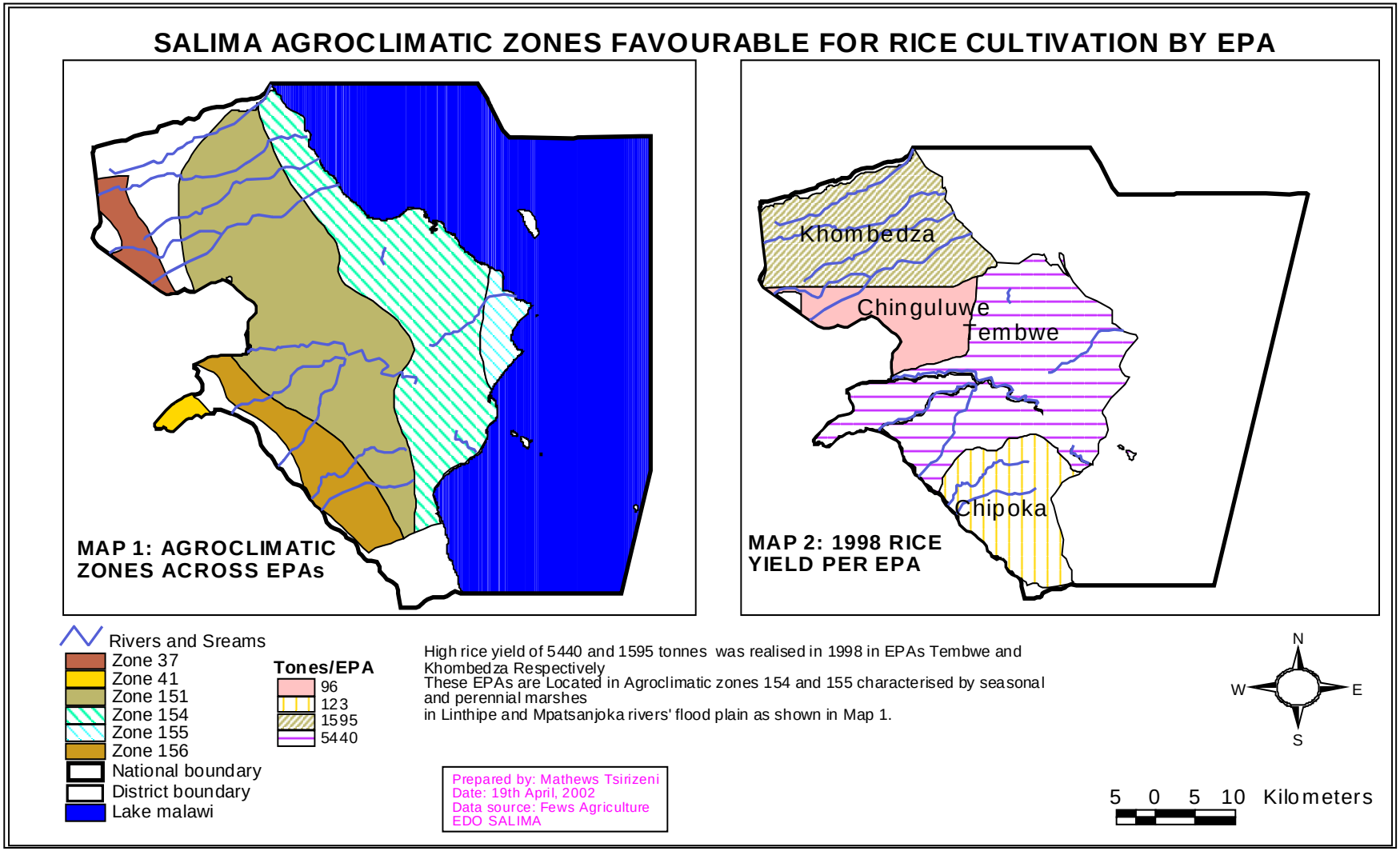
Map 4
Karonga Change in Land Utilization, 1973 - 1991
Prepared by Welton Phalira, EDO Coordinator, Environmental Affairs Department, Lilongwe



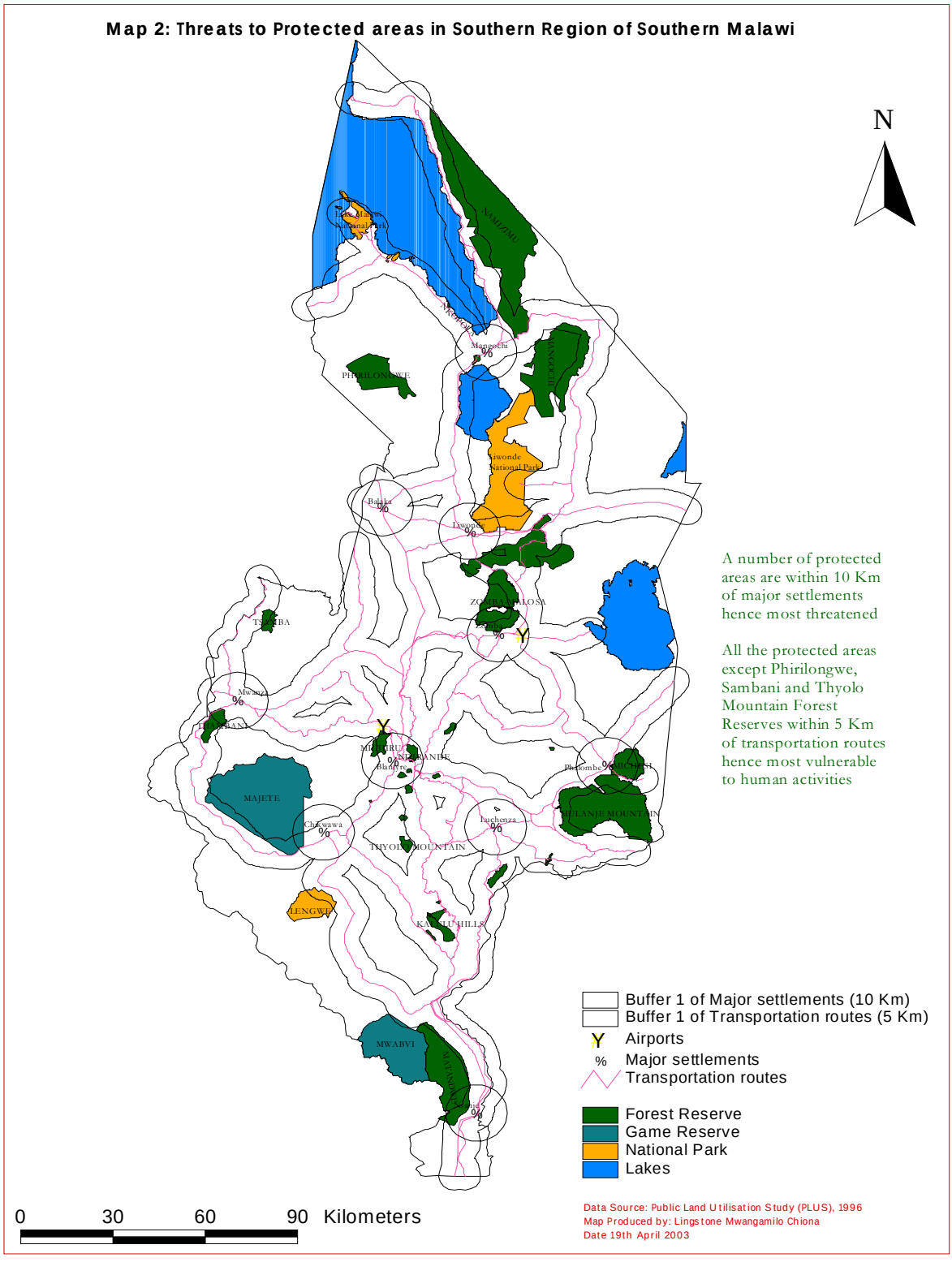
Map 5
The Effects of Tobacco Farming on Miombo Woodlands in Kasungu, 1973-1991
Prepared by Stephen Sakhama, District Environmental Officer, Kasungu



Map 6
Mzimba Land Cover Change, 1973-1991
Prepared by Symon Mandala, District Environmental Officer, Mzimba



Map 7
Agro-Climatic Zones Favorable for Rice Production in Salima
Prepared by Mathews Tsirizeni, District Environmental Officer, Salima



Map 8
Threats to Protected Areas in the Southern Region of Malawi
Prepared by Lingstone Chiona, District Environmental Officer, Mangochi

Attachment IV

Contents and Structure of the COMPASS GIS Resource Kit for Malawi CD

GIS FOR NATURAL RESOURCE MANAGERS

Contents and Structure of the CD – "GIS Resource Kit, Malawi"

The contents of the GIS for Natural Resource Managers CD are organized into folders and files. To help the reader distinguish between the two, the names of **folders** are printed in bold and the names of *files* are printed in italics.

The seven first-level folders on the CD are named as follows:

1. **Adobe**
2. **ArcExplorer Software and User Manual**
3. **Case Studies**
4. **GIS Data Dictionary**
5. **GIS Database**
6. **Maps**
7. **Useful Addresses on the World Wide Web**

The contents of each of these folders are described below.

1. **Adobe –** Contains the software and documentation needed to run Adobe Acrobat 5.0.5. This program is required to open and print documents stored in .pdf format.

2. **ArcExplorer Software and User Manual –** Contains two files:

   - *ae2setup.exe* – the executable file that will install ArcExplorer 2.0 on your computer.
   - *ArcExplorer.pdf* – the electronic version of the ArcExplorer User Manual in .pdf format. This is the document in Section B of your Resource Kit.

3. **Case Studies –** Four Adobe Acrobat (.pdf) files describing GIS applications in a range of natural resource management fields. Items marked * are included in Section F of the printed version of the GIS Resource Kit.

   - **Forest Monitoring in Malawi.pdf* – the article in the Resource Kit entitled "Forest Monitoring in Malawi using Long Time Series Vegetation Index Data". The article was written by Ronald Eastman and James Toledano of Clark University in the U.S.
   - *GIS for Africa*.pdf – An article published by ESRI describing the use of GIS in the context of sustainable economic development.
   - *GIS for Managing Forests.pdf* – Another ESRI publication, this one a two-page flyer describing how GIS is being used as a tool for managing forests in Ireland.
   - **Tracking Pesticide Use.pdf* – An article by Rosemary Neal about how the California Department of Pesticide Regulation uses GIS to monitor the use of pesticides.

4. **GIS Data Dictionary –** This folder contains one file - *GIS Data Dictionary.doc*. The Microsoft Word document describes the contents and structure of the geographic and attribute data contained in the folder **GIS Database**. The printed version of the GIS Data Dictionary is contained in Section D of your GIS Resource Kit.

5. **GIS Database –** This folder contains all the spatial data you will use with ArcView during this training course. The data are stored in three sub-folders called:

   A. GIS Layers
   B. Satellite Data
   C. Fews Agricultural Data.

   A. GIS Layers – Contains 24 layers of geographic data stored as ArcView shape files and their associated database and index files. The names of the layers, most of which are self-explanatory, are as follows:

   13. 1998 Census Enumeration Area
   14. Agricultural Schemes
   15. Agroclimatic Zones
   16. Airports
   17. COMPASS Districts
   18. Districts
   19. Extension Planning Areas
   20. Forest Reserves
   21. Lakes
   22. Landcover 1973
   23. Landcover 1991
   24. Major Settlements
   25. National Boundary
   26. National Parks
   27. Proposed Forest Reserves
   28. Protected Areas
   29. Regions
   30. Rivers and Streams
   31. Soils
   32. Traditional Areas
   33. Transportation Routes
   34. UTM Grid
   35. Vegetation
   36. Wildlife Reserves

   B. Satellite Data – Contains data from the Landsat 7 Enhanced Thematic Mapper (ETM+) sensor. The four files in the folder show two sub-scenes of data – one for the city of Lilongwe and one for the area around Bunda. The four files are:

   - Landsat Bunda.tfw
   - Landsat Bunda.tif
   - Landsat Lilongwe.tfw
   - Landsat Lilongwe.tif

   C. FEWS Agricultural Data – Comprised of three Microsoft Excel files containing agricultural area, yield and production data for 154 Extension Planning Areas. The three files are:

   - *EPAAREA.XLS*
   - *EPAYIELD.XLS*
   - *EPAPROD.XLS*

   A more detailed description of the GIS layers, satellite data and agricultural data is given in the GIS Data Dictionary.

6. **Maps –** The files in this folder are examples of the maps and GIS applications contained in Section G of the printed version of the Training Materials and Resource Kit. The folder also contains a draft of "Malawi – An Atlas of Social Statistics", published in September 2002 by the NSO and the International Food Policy Research Institute (IFPRI). The files in the folder are as follows:

    - *Imbirikani Ranch Land Use Plan.pdf* – A map showing the interim land use plan for the Imbirikani Group Ranch.
    - *Malawi Agricultural Schemes Map.doc* – the agricultural schemes map from the Resource Kit, stored as a Microsoft Word document.
    - *Malawi Agricultural Schemes Map.wmf* – the same map, stored as a Windows Metafile which can be imported as a graphic into Microsoft and many other software applications.
    - *Malawi Protected Areas.pdf* – contains both the map and the attribute table for Malawi's protected areas.
    - *Malawi_atlas_draft2.pdf* – the draft Malawi Atlas of Social Statistics.
    - *Malawi's Agricultural Schemes.pdf* – the attribute table associated with the agricultural schemes map.
    - *Sample Maps.doc* – A Microsoft Word document containing 7 sample maps produced by participants in the COMPASS GIS training course held in September 2002.

The Malawi Atlas of Social Statistics is not included in Section G of the printed version of the Resource Kit.

7. **Useful Addresses on the World Wide Web –** This folder contains one file called *GIS web links.doc*, a Microsoft Word document listing the addresses of twelve web sites that are useful sources of data and information related to GIS and natural resources management. Some of the sites provide free maps, reports and/or GIS data (Data Depot, NSO, Africa Data Dissemination Service, University of Texas, FEWS), others explain technical terms and concepts associated with the mapping sciences (University of Oregon, University of Edinburgh, United States Geological Survey), and others are specifically concerned with GIS and/or NRM in Malawi (MEMP, COMPASS, Project Africa). The list of useful WWW addresses is included in this report as Attachment V.

Attachment V

Useful Web Addresses for Malawian GIS Technicians

Useful Web Addresses

http://216.239.35.100/search?q=cache:F-o6gki1NB4C:www.nso.malawi.net/home.htm+Malawi+NSO&hl=en&ie=UTF-8

Home page of the Malawi National Statistical Office. Online versions of recent census data, Malawi in Figures and the Statistical Yearbook from 2001, Malawi's Strategic Plan for 2002-2006, and numerous other sources of socio-economic data.

http://www.compass-malawi.com/

Home Page of the Community Partnership for Sustainable Resource Management (COMPASS) web site. Describes COMPASS activities, results and grants management programme, and an excellent source of information about CBNRM-related publications, training programmes, best practices and partner organizations.

http://www.gisdatadepot.com/catalog/MI/

GIS DataDepot, a site offering free GIS data, including data for Malawi.

http://ag.arizona.edu/OALS/malawi/Malawi.html

Malawi Environmental Monitoring Program (MEMP) site, jointly hosted by the Office of Arid Lands Studies, University of Arizona, and Clarke University in Worcester, Massachusetts. Reports, papers, work plans, and maps, photographs and figures from the Public Lands Utilization Study (PLUS)

http://www.projectafrica.com/hippoexped2002.htm

Project Africa's 2002 Lake Malawi Hippo Expedition to conduct a comprehensive hippo census for the lake. The team will use GIS to manage and analyze the data. The expedition is scheduled for October, and they're looking for volunteers!

http://www.usgs.gov/research/gis/title.html

United States Geological Survey site – a good introduction to GIS terms, concepts and applications.

Useful Web Addresses

http://bsrsi.msu.edu/trfic/SAFARI2000/
http://sandmc.pwv.gov.za/safari2000/

Sites offering discounted and free satellite data for Malawi, including medium resolution Landsat data and high resolution IKONOS data.

http://glcfapp.umiacs.umd.edu:8080/glcf/images/esdi_head.gif

University of Maryland Earth Science Data Interface site, also offering discounted and free satellite data for Malawi and other countries.

http://www.geo.ed.ac.uk/agidict/welcome.html

A dictionary of GIS acronyms, abbreviations and jargon, published by the Association for Geographic Information at the University of Edinburgh, Scotland, UK.

http://edcsnw4.cr.usgs.gov/adds/adds.html

The Africa Data Dissemination Service, a source of GIS data for Malawi and other African countries. Maintained by the USGS and USAID, and closely related to FEWS NET

http://www.fews.net/

The Famine Early Warning System Network home page. Regularly updated reports about food security issues including flooding, drought, harvests, emergency response planning, crop prices and desertification. Links to sites devoted to food security issues in Malawi.

http://www.lib.utexas.edu/maps/africa.html

Electronic maps of most African countries, including Malawi. Political and relief maps available.

http://shiva.uoregon.edu/introGIS/lecture1.html

Notes from an introductory GIS lecture at the University of Oregon. Asks and answers some interesting questions.

www.esri.com

Home page of Earth Systems Resources Institute, producers of ArcExplorer, ARC/INFO and ArcView software.

Attachment VI

Data Dictionary for the COMPASS Malawi GIS Database

A. GIS Layers

File Name	Number of Features	Description	Attribute Field Name	Attribute Description
1998 census enumeration areas.shp	9,218	Boundaries of Census Enumeration Areas (EA's), as used in the 1997/98 household survey conducted by the NSO and IFPRI	Area	Area of each enumeration area in square metres
			Perimeter	Length of perimeter of each enumeration area in metres
			Eacode	Unique identification number for each enumeration area
			Tacode	Unique identification number for the TA each enumeration area is in
			Distcode	Unique identification number for the District each enumeration area is in
			Taname	Name of the TA each enumeration area is in
			District	Name of the district each enumeration area is in
			Eatype	Type of each enumeration area, classified as follows: - Boma/Township - Forest/Park - Lake (units defining lakes in the shape file) - Pop Area - Trading Centre
			Les50hh	
			Povmapward	
			X_coord	
			Y_coord	
			Hh	
			Hectares	Area of each enumeration area in hectares
			Sq_km	Area of each enumeration area in square kilometres

File Name	Number of Features	Description	Attribute Field Name	Attribute Description
Agroclimatic zones.shp	371	Boundaries of agro-climatic zones in Malawi, describing average annual variations in rainfall, temperature, number of dry months and length of growing period	Area	Area of each unit (feature) in square metres
			Perimeter	Length of perimeter of each unit (feature) in metres
			Hectares	Area of each unit (feature) in hectares
			Aczone	Agroclimatic zone codes assigned by LREP
			Lgp	Mean length of growing period in months/year
			Ppet	Ratio of precipitation to potential evapotranspiration
			Tgp	Mean temperature during growing period in degrees Celsius
			Pan	Mean annual precipitation (units not known)
			Dm	Mean number of dry months per year
			Tan	Mean annual temperature in degrees Celsius
			Tmin	Mean minimum temperature during coldest month in degrees Celsius
			Tegp	Mean temperature during end of growing period in degrees Celsius
			Sq_km	Area of each unit (feature) in square kilometres
Agricultural schemes.shp	44	Boundaries of agricultural schemes in Malawi	Area	Area of each agricultural scheme (feature) in square metres
			Perimeter	Length of perimeter of each agricultural scheme in metres
			Hectares	Area of each agricultural scheme (feature) in hectares
			Scheme_nam	Name of each agricultural scheme
			Scheme_id	Sequential identification number of each agricultural scheme
			Sq_km	Area of each agricultural scheme (feature) in square kilometres
Airports.shp	6	Locations of major airports in Malawi	Aeptname	Name of each airport
			Aeptval	Elevation of each airport in feet above mean sea level
			Aeptdate	Year database was last updated
			Long	Longitude of each airport in decimal degrees east of Greenwich
			Lat	Latitude of each airport in decimal degrees south of Greenwich
National boundary.shp	1	Boundary of Malawi	Area	Area of Malawi in square meters
			Perimeter	Length or Malawi's national boundary in meters
			hectares	Area of Malawi in hectares
			km_sq	Area of Malawi in square kilometres

File Name	Number of Features	Description	Attribute Field Name	Attribute Description
Major settlements.shp	20	Locations of major towns and cities in Malawi	Ppptname	name of settlement
			Long	settlement longitude in decimal degrees
			Lat	settlement latitude in decimal degrees
			Popul87	settlement population, 1987
Districts.shp	24	Boundaries of districts in Malawi	Area	Area of each district (feature) in square metres
			Perimeter	Length of perimeter of each district (feature) in metres
			Hectares	Area of each district (feature) in hectares
			Km_sq	Area of each district (feature) in square kilometres
			Dist_name	Name of each district
			Dis_popul	Population of each district, 1987
			Poorperson	Number of poor people in each district, 1998
			Zpoorperso	% of Malawi's poor people living in each district, 1998
			Ultrapoor	Number of ultra poor people living in each district, 1998
			Zultrapoor	% of Malawi's ultra poor population living in each district, 1998
			Zdistpoppo	% of each district's population classified as poor, 1998
			Estpop98	Estimated total population of each district, 1998
Compass districts.shp	9	Boundaries of priority COMPASS districts in Malawi	Area	Area of each COMPASS priority district (feature) in square metres
			Perimeter	Length of perimeter of COMPASS priority districts (features) in metres
			Hectares	Area of each COMPASS priority district (feature) in hectares
			Km_sq	Area of each COMPASS priority district (feature) in square kilometres
			Distname	Name of each COMPASS priority district
			Dispopul	Population of each COMPASS priority district, 1987
Traditional areas.shp	368	Boundaries of Malawi's Traditional Areas (TA's)	Tacode	NSO code numbers of individual TA's
			Sqkm	Area of each TA (feature) in square kilometres
			District	Name of district each TA is located in
			Taname	Name of each TA
			Distcode	NSO code number of district each TA is in
			Area	Area of each TA (feature) in square metres
			Perimeter	Length of perimeter of each TA (feature) in metres
			Hectares	Area of each TA (feature) in hectares

File Name	Number of Features	Description	Attribute Field Name	Attribute Description
Extension planning areas.shp	221	Boundaries of Extension Planning Areas (EPA's) in Malawi	Area	Area of each EPA (feature) in square metres
			Perimeter	Length of perimeter of each EPA (feature) in metres
			Hectares	Area of each EPA (feature) in hectares
			Km_sq	Area of each EPA (feature) in square kilometres
			Zid	FEWS identification code
			Popdns87	Number of inhabitants per km-sq, 1987
			Zname	Name of each EPA
			Zname2	Numeric name code
			Sam_id	Numeric code assigned by somebody called Sam!
			Pop87	EPA population, 1987
Proposed forest reserves.shp	36	Boundaries of proposed Forest Reserves in Malawi	Area	Area of each proposed Forest Reserve (feature) in square metres
			Perimeter	Length of perimeter of each proposed Forest Reserve in meters
			Name	Name of each proposed forest reserve
			Status	Status code, 0 or 4, meanings not known
			Hectares	area of each proposed Forest Reserve (feature) in hectares
			Km_sq	area of each proposed Forest Reserve (feature) in square kilometres
Forest reserves.shp	71	Boundaries of Forest Reserves in Malawi	Area	area of each forest reserve (feature), in square metres
			Perimeter	length of perimeter of each forest reserve (feature), in metres
			Hectares	area of each forest reserve (feature) in hectares
			Km_sq	area of each forest reserve (feature) in square kilometres
			Name	name of each forest reserve
Lakes.shp	4	Boundaries of Malawi's four major lakes	Place	name of each lake
			Area	Area of each lake, in square metres
			Perimeter	Length of perimeter of each lake (feature), in metres
			Hectares	Area of each lake (feature) in hectares
			Sq_km	Area of each lake (feature) in square kilometres

File Name	Number of Features	Description	Attribute Field Name	Attribute Description
Landcover 1973.shp	871	Boundaries of land cover units in Malawi, 1973	Area	Area of each land cover unit (feature), in square metres
			Perimeter	Length of perimeter of each land cover unit (feature), in metres
			Hectares	Area of each land cover unit (feature), in hectares
			Km_sq	Area of each land cover unit (feature), in square kilometres
			Landcode	1973 land cover type code, numeric (see “name” field below)
			Name	200 = Evergreen forest 201 = Miombo in hilly area 202 = Miombo in flat area 203 = Eucalyptus 204 = Gmelina 205 = Pine 207 = Tung 224 = Water 299 = Unclassified

File Name	Number of Features	Description	Attribute Field Name	Attribute Description
Landcover 1991.shp	1,785	Boundaries of land cover units in Malawi, 1991	Area	Area of each land cover unit (feature), in square metres
			Perimeter	Length of perimeter of each land cover unit (feature), in metres
			Hectares	Area of each land cover unit (feature), in hectares
			Km_sq	Area of each land cover unit (feature), in square kilometres
			Landcode	1991 land cover type code, numeric (see “name” field)
			Name	200 = Evergreen woodland 201 = Miombo in hilly area 202 = Miombo in flat area 203 = Eucalyptus plantation 204 = Gmelina plantation 205 = Pine plantation 206 = Rubber plantation 207 = Tung plantation 208 = Logged area 209 = Grass 210 = Dambo 211 = Savanna 212 = Agriculture in forest area 213 = Agriculture in grass area 214 = Arable land 215 = Coffee & Tea 216 = Sugar 217 = Tobacco & Maize 218 = Leucaena 219 = Rice scheme 220 = Marshy area 221 = Bare rock 222 = River bed or bare ground 223 = Built-up area 224 = Water surface 299 = Not classified

File Name	Number of Features	Description	Attribute Field Name	Attribute Description
National parks.shp	12	Boundaries of Malawi's five National Parks	Area	Area of each National Park (feature) in square metres
			Perimeter	Length of perimeter of each National Park (feature) in metres
			Hectares	Area of each National Park (feature) in hectares
			Km_sq	Area of each National Park (feature) in square kilometres
			Parkname	Name of each National Park
Protected areas.shp	87	Boundaries of Malawi's protected areas	Hectares	Area in hectares
			Km_sq	Area in square kilometres
			Name	Name of each Protected Area, uppercase text
			Type	Type of Protected Area, numeric codes described in "type_txt" field 100 200 300
			Type_txt	Type of Protected Area 100 = Forest Reserve 200 = Game Reserve 300 = National Park
			Name_low	Name of each Protected Area, lowercase text
			Prot_date	Year each PA given protected status
			Gaz_date	Year each PA gazetted
			Gaz_decade	Decade during which each PA gazetted
			Gaz_1964	Gazettement 1964 or earlier (1=yes, 2=no)
			Add_date	Date Agricultural Development District containing PA established
			Rationale1	Codes for primary reason each PA gazetted, listed in "r1_code" field

File Name	Number of Features	Description	Attribute Field Name	Attribute Description
Protected areas.shp (continued)			R1_code	1 = catchment protection 2 = water supply protection 3 = conservation of biodiversity 5 = fuelwood 6 = hardwood production 7 = softwood production 8 = research 12 = amenity value 13 = doubtful
			Rationale2	Codes for seconday reason each PA gazetted, listed in “r2_code” field
			R2_code	0 = no secondary rationale for creation 1 = catchment protection 2 = water supply protection 3 = conservation of biodiversity 4 = local construction 5 = fuelwood 6 = hardwood production 7 = softwood production 8 = research 11 = sleeping sickness risk 12 = amenity value
			Rationale3	Codes for tertiary reason each PA gazetted, listed in “r3_code” field
			R3_code	0 = no tertiary rationale for creation 4 = local construction 6 = hardwood production 7 = softwood production 9 = grazing 12 = local construction
			Rationale4	Codes for quaternary reason each PA gazetted, listed in “r4_code” field
			R4_code	0 = no quaternary rationale for creation 5 = fuelwood
			Buffer_pop	1987 population within 5km of each Protected Area

File Name	Number of Features	Description	Attribute Field Name	Attribute Description
Regions.shp	5	Boundaries of Malawi's three regions	Area	Area of each region (feature) in square metres
			Perimeter	Length of perimeter of each region (feature) in metres
			Hectares	Area of each region (feature) in hectares
			Km_sq	Area of each region (feature) in square kilometres
			Rname	Name of each region ("north", "center", "south")
Soils.shp	241	Boundaries of soils units for all Malawi	Area	Area of each soil unit (feature) in square metres
			Perimeter	Length of each soil unit (feature) in metres
			Hectares	Area of each soil unit (feature) in hectares
			Km_sq	area of each soil unit (feature) in square kilometres
			Soil-id	Soil unit identification code
			Soil_type	Alphanumeric soil type code (meaning of codes not known)
			Assoc_1	Primary soil association, alphanumeric code (meanings not known)
			Assoc_2	Secondary soil association, alphanumeric code (meanings not known)
			Assoc_3	Additional soil association, alphanumeric code (meanings not known)
			Assoc_4	Additional soil association, alphanumeric code (meanings not known)
			Includ_1	Primary soil inclusion type code (meanings not known)
			Includ_2	Secondary soil inclusion type code (meanings not known)
			Includ_3	Additional soil inclusion type code (meanings not known)
			Includ_4	Additional soil inclusion type code (meanings not known)

File Name	Number of Features	Description	Attribute Field Name	Attribute Description
Rivers and streams.shp	1,263	Rivers and streams of Malawi	Dnlntype	Drainage network line type code, described in dnlntypetx field 1 2 9
			Dnlntypetx	Drainage network line type description, text 1 = streams, rivers or channelized rivers 2 = inland shorelines 9 = tile boundary or null arc
			Dnlnstat	Drainage line status described in dnlnstattx field 1 3 99
			Dnlnstattx	Drainage network line status description 1 = perennial 3 =definite, used for inland shorelines only 99 = none
			Kilometres	Length of stream or river section (feature) in kilometres
Transportation routes.shp	343	Roads of Malawi	Length	Length of road segment (feature) in metres
			Sym	Line symbol code, numeric 13 = Primary roads 14 = Secondary roads 15 = Railways
			Kilometres	Length of road segment (feature) in kilometres
Wildlife reserves.shp	4	Boundaries of Malawi's four Wildlife Reserves	Area	Area of Wildlife Reserve (feature) in square metres
			Perimeter	Length of perimeter of Wildlife Reserve (feature) in metres
			Hectares	Area of Wildlife Reserve (feature) in hectares
			Km_sq	Area of Wildlife Reserve (feature) in square kilometres
			Wresname	Name of Wildlife Reserve

File Name	Number of Features	Description	Attribute Field Name	Attribute Description
Vegetation.shp	155	Boundaries of vegetation cover units for all of Malawi	Area	Area of vegetation unit (feature) in square metres
			Perimeter	Length of perimeter of vegetation unit (feature) in metres
			Hectares	Area of vegetation unit (feature) in hectares
			Sq_km	Area of vegetation unit (feature) in square kilometres
			Vcode	Vegetation category code, defined in “Legend” field
			Legend	1 = Montane evergreen forest 2 = Montane grassland 3 = Semi-evergreen forest 4a = Closed-canopy woodland of wetter uplands 4b = Open-canopy woodland of plateaux 4c = Open-canopy woodland of hills and scarps 4d = Open-canopy woodland of fertile areas 5a = Mopane woodland 5b = Woodlands of fertile areas 5c = Thicket/Savanna of poorer areas 5d = Woodland/Savanna (mixed species) 6 = Sand dune vegetation 7a = Woodlands of wet fringes (Terminalia Sericea) 7b = Grasslands – seasonally wet 9 = Islands
Utm grid.shp	93	UTM grid covering Shire Valley	Length	Length of each section of grid (feature) in metres (50,000m)
			Utmgridlin	Metres east (E) of central meridian or north (N) of reference latitude
			Kilometres	Length of each section of grid (feature) in kilometres (50km)

B. Satellite Data

Description: Two subsets of a Landsat ETM+ scene showing general land cover characteristics in and around Lilongwe and Bunda College. The data were captured on 2 June 2002.

Geographic Coverage: a) City of Lilongwe, b) the area around Bunda College.

File Names: a) Landsat Lilongwe.tif, b) Landsat Bunda.tif

Format: GeoTIF format (.tif) with coordinates stored in UTM meters, Zone 36 South.

C. FEWS Agricultural Data

Description: Agricultural production data for 13 different crops in 154 Extension Planning Areas (EPAs).

Crops:

1984 - 1998	1994 - 1998
Long Season Maize	Composite Maize
Hybrid Maize	Pulses
Cassava	Sorghum
Rice	Potato
Groundnuts	Sweet Potato
	Tobacco
	Millet
	Cotton

Format:
3 Microsoft Excel (xls) files -
EPAAREA.XLS – annual area planted to each crop (hectares)
EPAYIELD.XLS – average yield of each crop (tonnes/hectare)
EPAPROD.XLS – annual production (tonnes)

Source: FEWS, Lilongwe

Attachment VII – COMPASS Publications

Document Number	Title	Author(s)	Date
Document 1	COMPASS Year 1 Work Plan	COMPASS	Jul-99
Document 2	COMPASS Small Grants Management Manual	Umphawi, A., Clausen, R., Watson, A.	Sep-99
Document 3	Year 2 Annual Work Plan	COMPASS	Dec-99
Document 4	July 1 - September 30, 1999: Quarterly Report	COMPASS	Oct-99
Document 5	Training Needs Assessment: Responsive Modules & Training Approach	Mwakanema, G.	Nov-99
Document 6	Guidelines and Tools for Community-Based Monitoring	Svendsen, D.	Nov-99
Document 7	Policy Framework for CBNRM in Malawi: A Review of Laws, Policies and Practices	Trick, P.	Dec-99
Document 8	Performance Monitoring for COMPASS and for CBNRM in Malawi	Zador, M.	Feb-00
Document 9	October 1 - December 31, 1999: Quarterly Report	COMPASS	Jan-00
Document 10	Workshop on Principles and Approaches for CBNRM in Malawi: An assessment of needs for effective implementation of CBNRM	Watson, A.	Mar-00
Document 11	January 1 - March 31, 2000: Quarterly Report	COMPASS	Apr-00
Document 12	Thandizo la Ndalama za Kasamalidwe ka Zachilengedwe (Small Grants Manual in Chichewa)	Mphaka, P.	Apr-00
Document 13	Njira Zomwe Gulu Lingatsate Powunikira Limodzi Momwe Ntchito Ikuyendera (Guidelines and Tools for Community-based Monitoring in Chichewa)	Svendsen, D. - Translated by Mphaka, P. and Umphawi, A.	May-00
Document 14	Grass-roots Advocacy for Policy Reform: The Institutional Mechanisms, Sectoral Issues and Key Agenda Items	Lowore, J. and Wilson, J.	Jun-00
Document 15	A Strategic Framework for CBNRM Media Campaigns in Malawi	Sneed, T.	Jul-00
Document 16	Training Activities for Community-based Monitoring	Svendsen, D.	Jul-00
Document 17	April 1 - June 30, 2000: Quarterly Report	COMPASS	Jul-00
Document 18	Crocodile and Hippopotamus Management in the Lower Shire	Kalowekamo, F.	Sep-00
Document 19	Cost-Sharing Principles and Guidelines for CBNRM Activities	Moyo, N.	Sep-00
Document 20	Workplan: 2001	COMPASS	Nov-00
Document 21	July 1 - September 30, 2000: Quarterly Report	COMPASS	Oct-00

Document 22	Opportunities for Sustainable Financing of CBNRM in Malawi: A Discussion	Watson, A.	Nov-00
Document 23	Framework for Strategic Planning for CBNRM in Malawi	Simons, G.	Nov-00
Document 24	Kabuku Kakwandula Ndondomeko ya Thumba Lapadera la Wupu wa COMPASS (Chitumbuka version of the COMPASS Small-grant Manual)	Umphawi, A., Clausen, R. & Watson, A. Translated by Chirwa, T.H. & Kapila, M.	Dec-00
Document 25	COMPASS Performance and Impact: 1999/2000	COMPASS	Nov-00
Document 26	October 1 - December 31, 2000: Quarterly Report	COMPASS	Jan-01
Document 27	COMPASS Grantee Performance Report	Umphawi, A.	Mar-01
Document 28	January 1 - March 31, 2001: Quarterly Report	COMPASS	Apr-01
Document 29	Natural Resource Based Enterprises in Malawi: Study on the contribution of NRBEs to economic development and community-based natural resource management in Machinga District	Lowore, J.	Apr-01
Document 30	Proceedings of the First National Conference on CBNRM in Malawi	Kapila, M., Shaba, T., Chadza, W., Yassin, B. and Mikuwa, M.	Jun-01
Document 31	Natural Resource Based Enterprises in Malawi: Action Plans	Watson, A.	Jun-01
Document 32	Examples of CBNRM Best Practices in Malawi	Moyo, N. & Epulani, F.	Jun-01
Document 33	Media Training for CBNRM Public Awareness	Kapila, M.	Jun-01
Document 34	April 1 - June 30, 2001: Quarterly Report	COMPASS	Jul-01
Document 35	Strategic Plan for CBNRM in Malawi	CBNRM Working Group	Sep-01
Document 36	Workplan: 2002	COMPASS	Oct-01
Document 37	July 1 - September 30, 2001: Quarterly Report	COMPASS	Oct-01
Document 38	COMPASS Performance and Impact: 2000/2001	COMPASS	Dec-01
Document 39	Coordination of CBNRM in Malawi: Financing Options	Watson, A.	Jan-02
Document 40	Performance Monitoring for CBNRM in Malawi	CBNRM Working Group	Oct-02
Document 41	October 1 – December 31, 2001: Quarterly Report	COMPASS	Jan-02
Document 42	COMPASS Field Level Training Impact Evaluation	Moyo, N.	Feb-02
Document 43	COMPASS Grantee Performance Report: 2001	Umphawi, U.	Apr-02
Document 44	COMPASS Assessment: 2001	Sambo, E., Carr, S., Omambia, D. & Moore, T.	Apr-02
Document 45	January 1 - March 31, 2002: Quarterly Report	COMPASS	Apr-02
Document 46	Community Tourism and Enterprise Training Manual	Kacal, S.	Jun-02

Document 47	Charcoal, Chiefs and Chambo: Status of CBNRM Policies in Malawi	Trick, P. & Manning, L.	Jun-02
Document 48	April 1 - June 30, 2002: Quarterly Report	COMPASS	Jul-02
Document 49	Business Development Services for Natural Resource Based Enterprises	Magai, G. & Nthambi, T.	Sep-02
Document 50	July 1 – September 30, 2002: Quarterly Report	COMPASS	Oct-02
Document 51	Workplan: 2003	COMPASS	Oct-02
Document 52	COMPASS Performance and Impact: 2001/2002	COMPASS	Oct-02
Document 53	GIS for Natural Resources Managers	Craven, D.	Nov-02
Document 54	Proceedings of the Second National Conference on CBNRM in Malawi	Malembo, L., Chadza, W., Kamuloni, S. & Kanjedza, R.	Dec-02
Document 55	Impact of HIV/AIDS on Natural Resource Management in Malawi	Page, S.	Apr-03
Document 56	October 1 – December 31, 2002: Quarterly Report	COMPASS	Jan-03
Document 57	The Role of the Private Sector in CBNRM in Malawi	Watson, A.	Jan-03
Document 58	COMPASS Grantee Perfromance: 2002	Ndovi, W. & Godfrey, G.	Apr-03
Document 59	COMPASS Gender Policy Development Workshop	Omambia, D.	Mar-03
Document 60	January 1 – March 31, 2003: Quarterly Report	COMPASS	Apr-03
Internal Report 1	Building GIS Capabilities for the COMPASS Information System	Craven, D.	Nov-99
Internal Report 2	Reference Catalogue (2nd Edition)	COMPASS	Feb-01
Internal Report 3	Workshop on Strategic Planning for the Wildlife Society of Malawi	Quinlan, K.	Apr-00
Internal Report 4	Directory of CBNRM Organizations (2nd Edition)	COMPASS	Jan-01
Internal Report 5	Proceedings of Water Hyacinth Workshop for Mthunzi wa Malawi	Kapila, M. (editor)	Jun-00
Internal Report 6	COMPASS Grantee Performance Report	Umphawi, A.	Jun-00
Internal Report 7	Examples of CBNRM Best-Practices in Malawi	Moyo, N. and Epulani, F.	Jul-00
Internal Report 8	Software Application Training for COMPASS	Di Lorenzo, N.A.	Sep-00
Internal Report 9	Directory of COMPASS ListServ Members	Watson, A.	Jan-01
Internal Report 10	Introductory Training in Applications of Geographic Information Systems and Remote Sensing	Kapila, M.	Feb-01
Internal Report 11	COMPASS TAMIS Grants Manual	Exo, S.	Mar-01
Internal Report 12	Review of Recommendations of the Lake Chilwa and Mpoto Lagoon Fisheries By-Laws Review Meeting	Nyirenda, K.	May-01
Internal Report 13	End-of-Term Evaluation of the Co-Ordination Unit for the Rehabilitation of the Environment (CURE)	Sambo, E.Y.	Sep-01

Internal Report 14	Mwabvi Wildlife Reserve Co-Management Agreement Negotiations	Betha, M.R.B.	Feb-03
Internal Report 15	Reducing Vulnerability to HIV/AIDS among COMPASS Grantees	Page, S.	Mar-03
Internal Report 16	COMPASS Gender Policy	Omambia, D.	Mar-03